



Identifying and evaluating measures to decarbonising the mining value chain

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Outline

Emissions Diagnostic Approach: The research maps energy use and emissions across six major mineral sectors, distinguishing Scope 1, 2, and 3 emissions.



Decarbonisation Technologies: Emerging clean technologies are evaluated for maturity and feasibility in South Africa.



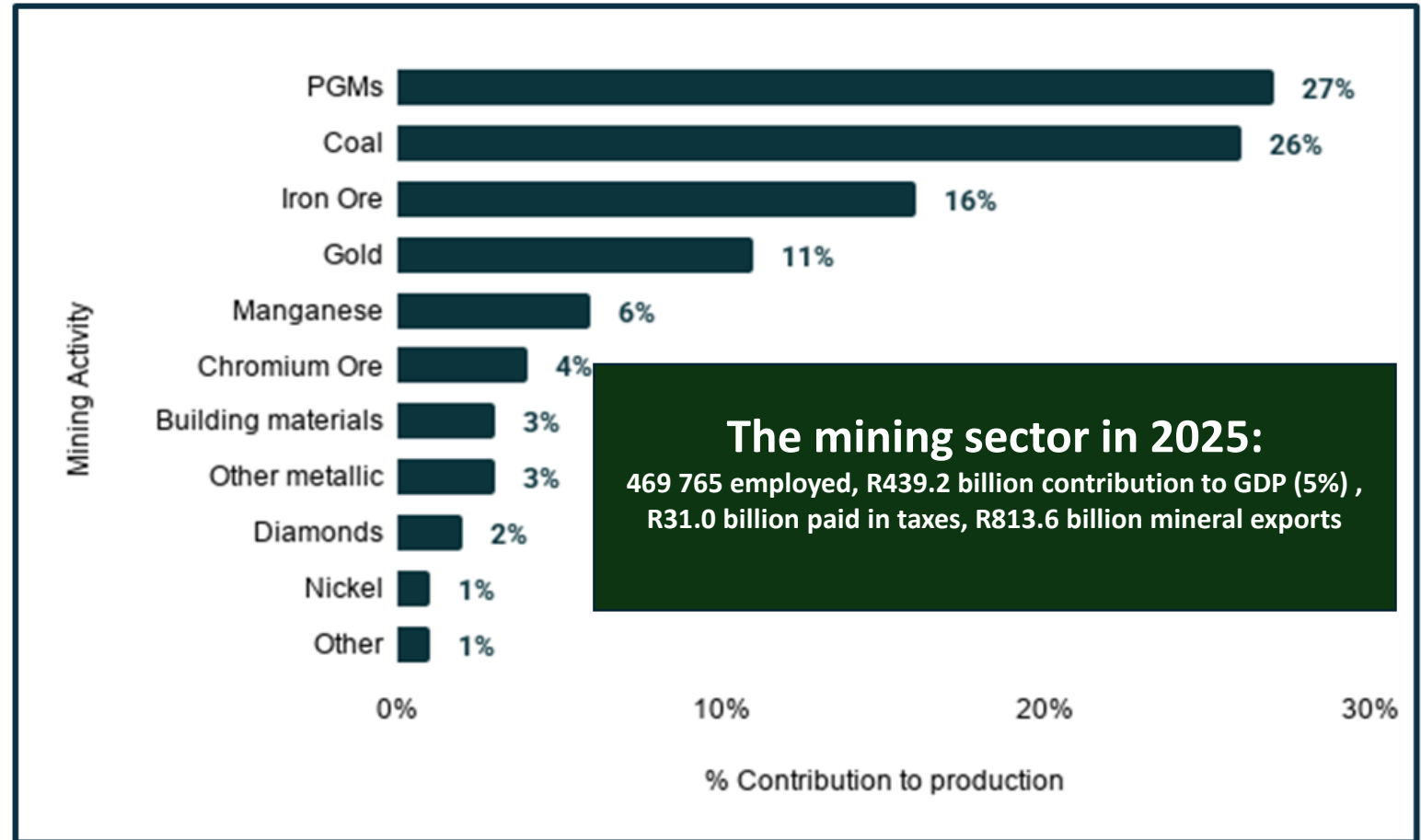
Regulatory and Policy Frameworks: How South Africa's regulatory policies influence corporate decisions and financing for emissions reduction.



Socio-Economic Impact Assessment: The study examines how decarbonisation affects stakeholders

Context

- **Economic Importance of Mining**
 - Mining significantly contributes to South Africa's exports, GDP, and employment, anchoring many local communities.
- **Challenges of Decarbonisation**
 - High energy use and fossil fuel reliance make mining a hard-to-abate sector requiring complex decarbonisation strategies.
- **Balancing Climate Change Commitments and Socio-Economics**
 - Decarbonising must protect jobs and communities while maintaining competitiveness with global counterparts



Source: Minerals Council ,2026. Launch of the Facts and Figures 2025 Pocketbook.

Defining Emission Scopes in Mining

EMISSIONS TYPE	SCOPE	DEFINITION	EXAMPLES IN MINING
Direct emissions	Scope 1	Emissions from sources owned or controlled by the company	Emissions from fuel combustion and chemical processes in boilers, furnaces, vehicles, and other equipment owned or controlled by the company
Indirect emissions	Scope 2	Emissions from purchased electricity, steam or heat	Use of purchased electricity, steam, heat, or cooling.
Other indirect emissions	Scope 3	Emissions occurring outside company control	Production of purchased products, transportation of purchased products, or use of sold products.

Mineral Value Chain Emission Analysis

Coal

- Primary Emissions: Fugitive methane, diesel use, discard coal fires (high Scope 3)
- Trade & Regulation Exposure: Declining demand; coal phase out policies
- Decarbonisation Levers: Methane abatement, renewables, discard-dump rehabilitation
- Key Constraints: Local socioeconomic reliance; methane capture limits; carbon-intensive grid

Iron and Steel

- Diesel in mining; electricity processing; coal/coke combustion
- High exposure to EU CBAM and global carbon pricing regimes
- Renewable electricity adoption; transition to low-carbon steelmaking (e.g., DRI , green hydrogen etc)
- Technological offtake; high capital costs for low carbon steel transformation

Gold

- Electricity for deep-level cooling, hoisting, ventilation; limited Scope 1 emissions from generators and vehicle fleets
- Indirect exposure via high grid emission factors; limited direct trade policy risk
- Renewable power procurement; energy efficiency in cooling and ventilation systems
- Depth-driven increases in energy demand; declining ore grades; financial risk due to mine closures

Mineral Value Chain Emission Analysis...

Non-Ferrous Metals (Aluminium, Copper, etc.)

- Primary Emission Sources: Extremely high electricity demand in aluminium smelting; moderate emissions from copper and other metals
- Trade & Regulatory Exposure: High vulnerability to carbon pricing and emissions-based competitiveness pressures
- Decarbonisation Options: Renewable electricity sourcing; efficiency upgrades; inert-anode technologies; increased recycling
- Key Constraints: Dependence on coal-based national grid; long-term electricity supply contracts; high electricity intensity

Platinum Group Metals

- Electricity-intensive deep-level mining and smelting; minimal diesel-related Scope 1 emissions
- Exposure to shifts in global automotive technology (ICE decline, growth in hydrogen sector)
- Renewable energy procurement; mining and smelting efficiency upgrades; leveraging PGM role in hydrogen technologies
- Depth-related energy intensity; grid instability; global technology-driven demand volatility

Ferro Alloys (Chromium, Manganese)

- Electricity intensive submerged arc furnaces; coal/coke reductant use; diesel emissions in upstream mining
- Exposure to CBAM; dependence on export markets, especially China
- Renewable energy procurement; smelter upgrades; fuel substitution including hydrogen
- High electricity tariffs; smelter closures due to cost pressures

Evaluating Technology Options

1. Electricity Generation

- Large-scale solar PV , Wind power via PPAs and wheeling, Battery Energy Storage Systems (BESS)
- Anglo American (Envusa Energy 3–5 GW pipeline); Sibanye Stillwater (175 MW); Implats (renewable PPAs); Exxaro (70 MW solar); ArcelorMittal SA (planned 200 MW solar); Gold Fields (50 MW solar) etc
- TRL 8–9 : Mature and scaling at industry level

2. Mining Operations

- Hydrogen–battery haul truck, BEVs, ventilation on demand, cooling, methane capture
- Anglo (hydrogen truck), Implats (electrification), ARM (BEV), Exxaro (methane)
- TRL 6–7: Pilots, demonstrations, early commercialisation

3. Refining & Smelting

- Closed furnaces and pelletised feed systems, Pre-heating technologies lowering thermal demand, Renewable PPAs , AP3XLE potline upgrades , Inert anode R&D to eliminate process emissions, Electric Arc Furnace (EAF) transition
- Merafe/Glencore (100 MW solar for chrome smelters), Samancor (100 MW Tubatse solar), Hillside Aluminium (AP3XLE upgrades)
- TRL 3–6 : Early-stage R&D to proven operational efficiency technologies

4. Transport & Logistics

- Hydrogen freight corridors, BEVs
- Anglo (hydrogen corridor), ARM (EV pilots)
- TRL 4–6: Emerging, field-tested, early implementation

5. Downstream Scope 3

- Coal phase-down, recycling, tailings re-mining, circularity
- Anglo American (exit from thermal coal), South32 (coal divestment pathway), Exxaro (coal-to-renewables transition), Seriti Resources (renewable energy to reduce coal exposure)
- TRL 5–7: Established but scaling across value chains

Corporate Decarbonisation Framework



Strategic pillars by major mining companies to achieve their 2030 and 2050 targets



Renewable Energy Integration

Mining firms are investing in large-scale solar and wind projects to reduce reliance on traditional power sources and lower emissions.



Innovative Low-Carbon Technologies

Companies pilot hydrogen-powered haul trucks, battery-electric underground vehicles, and automation to boost safety and reduce Scope 1 emissions.



Process Improvements in Value Chains

Energy-intensive sectors explore electric arc furnaces, renewable-powered smelters, and efficiency upgrades to cut carbon footprints.



Challenges and Support Needs

Smaller producers face financial barriers; industry calls for regulatory clarity, grid access, and financing to accelerate decarbonisation.

• How Mines Can Be Energised for Competitiveness:

- Electrified operations that progressively phase out diesel reliance
- Gas as a transitional fuel to support cleaner, flexible energy supply
- Diversified energy mix combining wind, solar, gas and storage
- Modular and interconnected systems that enhance resilience and scalability
- Expanded BESS capacity to stabilise supply and accelerate renewable integration can enable mines to be energised

Policy and Regulatory Framework

- **IRP:** Shapes long term electricity tariffs and the carbon intensity of grid supplied power, directly influencing Scope 2 emissions and informs decisions on self generation, electrification and wheeling.
- **National GHG Reporting:** Ensures mining companies maintain accurate Scope 1, Scope 2 and relevant Scope 3 inventories, supporting tighter regulatory oversight and improved internal decarbonisation planning.
- **EU CBAM, U.S. tariffs and global net-zero import rules** are exposing South Africa's emissions-intensive exports to rising compliance and cost risks.



Carbon Tax Act (2019)

Creates a rising price signal for Scope 1 emissions while allowances soften short-term cost impacts but still incentivise efficiency, fuel switching and investment in lower-carbon self-generation



Climate Change Act 22 (2024)

Introduces mandatory, sector-specific carbon budgets and mitigation plans with punitive non-compliance fines



Electricity Regulation Act

Enables private sector participation in electricity generation; removes licensing thresholds; facilitates market access for self generation.



National Energy Regulator Act 40 (2004)

Directly affects the cost and regulatory conditions for mining self generation, PPAs and wheeling arrangements, influencing Scope 2 emissions.



REIPPPP and the Renewable Energy Masterplan

Renewable energy supply available for corporate procurement and supports long term cost reductions for cleaner power used across mining value chains.

Insights from SEAIS



Social, Labour & Regulatory Drivers

- Increasingly stringent climate regulation
- Expanding disclosure requirements: CDP, TCFD, ISSB and investor-driven ESG reporting
- Labour concerns identified in the SEIAS process:
- Unclear employment impacts and worker pathways
 - Labour engagement is often tokenistic, limited inclusion in planning
 - Insufficient investment in reskilling and human-capital development for new technologies



Financial & Market Pressures

- Rising costs from carbon pricing, emissions penalties and energy tariffs
- Growing risk of stranded assets in high-emissions value chains (coal, ferro-alloys, steel)
- Investors and financiers tightening climate-risk criteria, elevating funding barriers for non-compliant firms



Trade & Competitiveness Risks

- Exposure to global net-zero import standards
- High-carbon exports (iron, steel, aluminium, ferro-alloys) facing declining competitiveness and higher compliance costs
- Risk of losing market share to lower-carbon producers across Asia and the Middle East



Operational & Infrastructure Risks

- Energy insecurity: load-shedding, grid instability and high electricity tariffs
- Ageing grid and infrastructure limiting renewable integration and technology deployment
- Rising electricity requirements for deep-level mining (ventilation, hoisting, cooling) under warming conditions



Environmental & Social License Risks

- Increased scrutiny on land use, water consumption, biodiversity loss and tailings management
- Community tensions where decarbonisation threatens local employment or economic stability
- Heightened expectations for just transition planning in coal-dependent provinces (e.g., Mpumalanga)

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- Strong mineral endowments (PGMs, Mn, Cr, Fe) that support global green-tech supply chains
- Active industry deployment of renewables and efficiency technologies
- High abatement potential via renewable PPAs and wheeling in electricity-intensive value chains

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- Heavy reliance on a coal-intensive grid driving high Scope 2 emissions.
- Key technologies still immature (hydrogen, inert anodes, H₂-DRI).
- High capital costs and limited financing access for mid-tier firms
- Grid bottlenecks, slow approvals, and wheeling constraints delay renewable uptake
- Coal-dependent regions face socio-economic vulnerability and transition risks

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- Global demand growth for critical minerals used in EVs, hydrogen, and batteries
- Falling renewable energy costs improve project viability and energy security
- Licensing reforms enable large-scale self-generation and private grid investment
- Circular-economy pathways (tailings re-mining, recycling, waste valorisation).

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- EU CBAM, U.S. tariffs, and net-zero import standards raising export risks
- High electricity tariffs undermine smelter viability
- Risk of stranded assets due to slow technology maturation and high capex
- Competition from low-cost regions with cheaper energy and relaxed climate rules
- Social instability if coal regions face unmanaged transition impacts

What we have learnt

- Electricity decarbonisation is the primary emissions lever
- Rapid decarbonisation of the electricity system is the most immediate and effective pathway to reduce sector-wide emissions
- Technology deployment remains uneven across value chains, reflecting variations in energy intensity and technological readiness
- Grid constraints and ageing infrastructure continue to act as major bottlenecks for large-scale decarbonisation
- Renewable energy remains the most mature and widely deployable decarbonisation option currently available
- A coherent transition requires alignment between energy policy, industrial strategy, and social and labour priorities

Coordinated Policy Pathways for Clean Transition

- Integrated Policy Framework
 - A coherent policy framework harmonizes energy, industrial, climate, and social policies for effective mining sector transition.
- Electricity Market Reforms
 - Reforms like grid upgrades and renewable procurement reduce emissions and support sustainable mining operations.
- Social and Economic Support
 - Social policies and economic diversification prevent worker displacement and support community resilience.

Thank you

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